Beamline Overview

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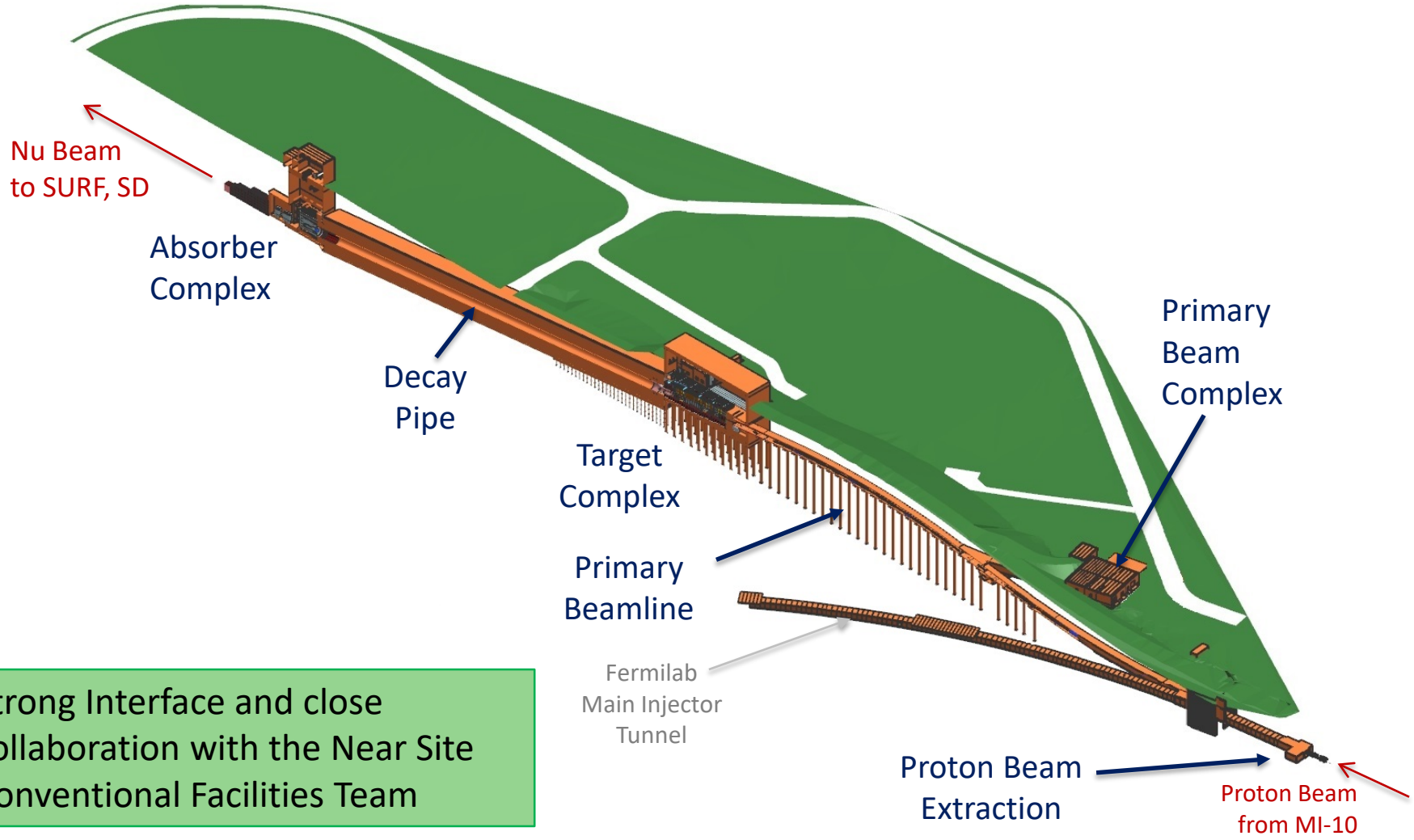
Horn A Prototype Final Design Review

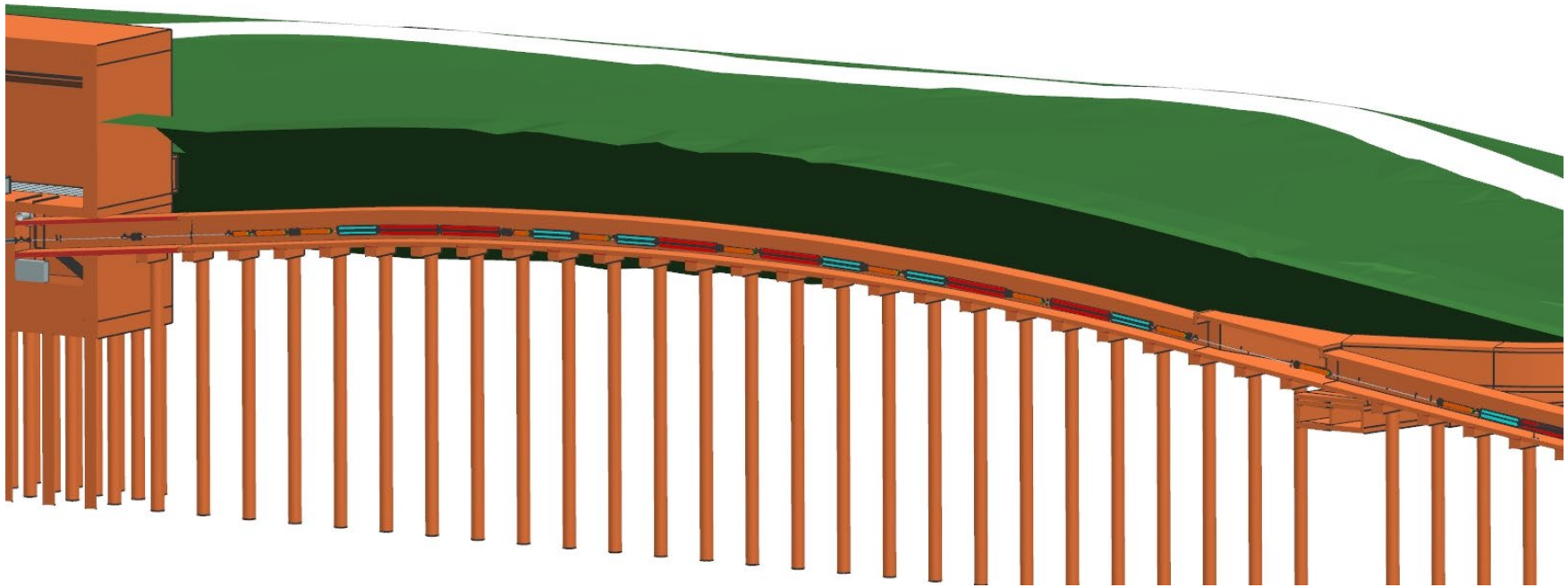
26 January 2021

Scope: Beamline Technical Components



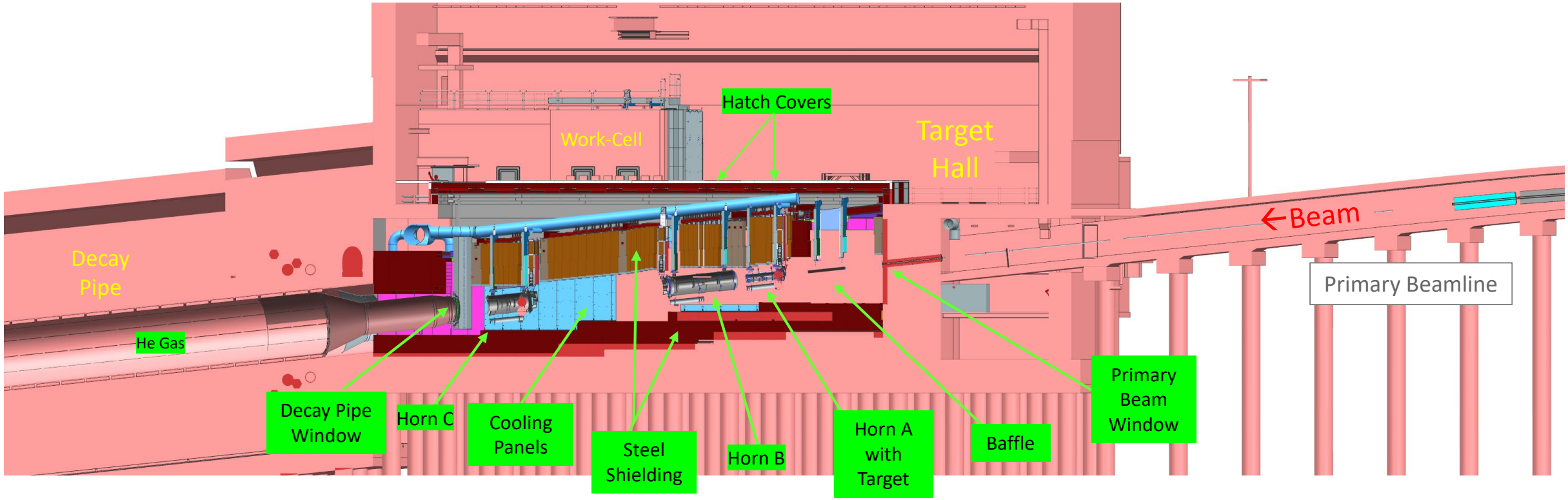
Strong Interface and close collaboration with the Near Site Conventional Facilities Team

Primary Beam Complex



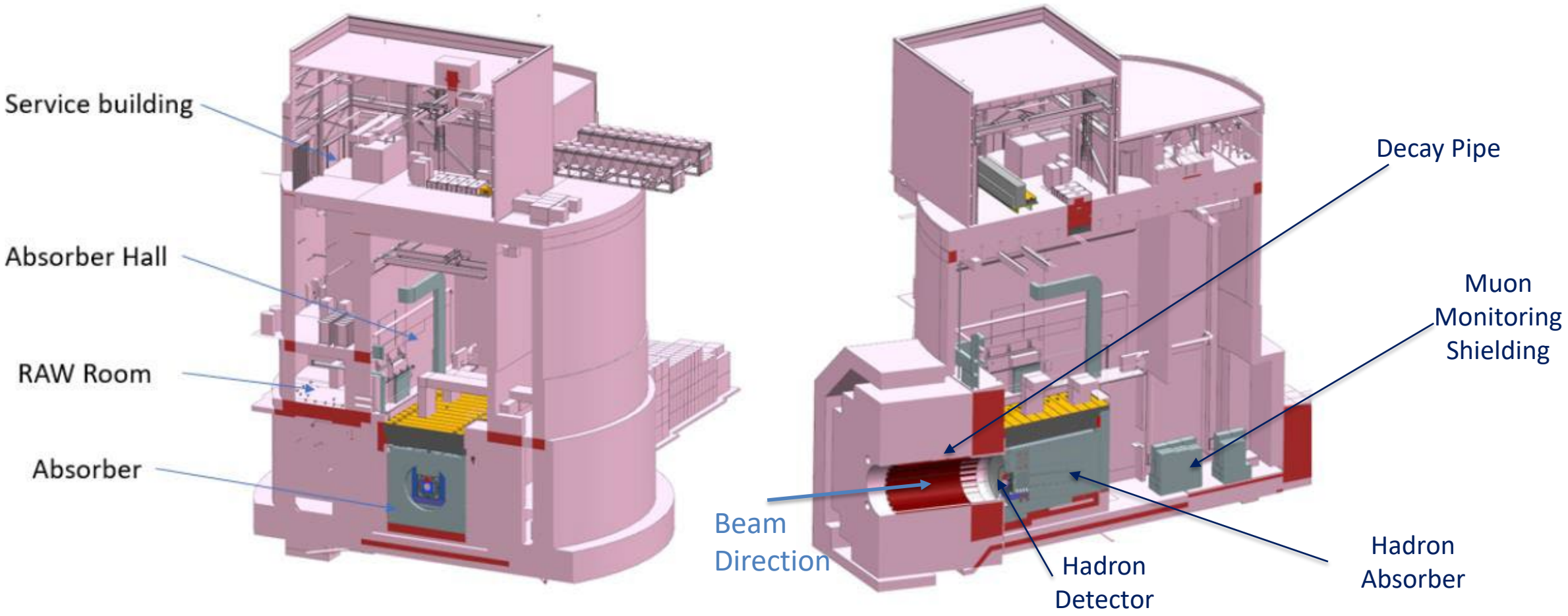
- Beam optics, magnets, magnet power supplies, water systems, vacuum, beam instrumentation, installation
  - International contributions
    - Corrector Magnets: IHEP, China (delivered 11/20)
    - Main Dipole & Quadrupole Magnets: BARC, India

Target Complex



- Baffle, target, focusing horns, support modules, horn power supply, target shield pile, radioactive water systems, remote handling, storage of radioactive components
- International Contributions:
  - Target, Baffle and associated systems: UKRI
  - Stripline Feedthrough & Hatch Cover Prototypes: KEK-JPARC, Japan

Decay Pipe and Absorber



- Primary beam window, decay pipe cooling and windows, hadron absorber, hadron monitor, muon systems

Beamline Requirements & Assumptions

- Driving physics considerations for the LBNF Beamline are the long baseline neutrino oscillation analyses.
- Beam directed towards SURF in Lead, South Dakota, 1300 km from Fermilab (5.8 degree overall vertical bend).
- Primary beam, single turn extracted from MI, is designed to transport high intensity protons in the energy range of 60-120 GeV to the LBNF target.
- Broad band, sign selected neutrino beam with its spectrum to cover the 1st (2.4 GeV) and 2nd (0.8 GeV) oscillation maxima => covering 0.5 ~ 5.0 GeV.
- Uptime (including the accelerator complex) of at least 55%

Beamline Requirements & Assumptions Contd.

- All systems are designed for 1.2 MW initial proton beam power and facility is upgradeable to 2.4 MW proton beam power.
- All systems that are prone to failure, such as water-cooled systems, are designed to be repairable and/or replaceable.
- Overall, LBNF can take up to 20% of lab's offsite radiation dose budget with stringent limits placed on radiological protection of environment, workers and the public. Self imposed 30% limit of lab's radioactive air emissions "cap". Entire facility encapsulated in water-proof barrier.
- Facility assumed to operate for 20 years within a 30 year span. Design life of Target & Absorber Hall Complexes and of Decay Pipe is 50 years.

Beamline Operating Parameters

$(1.1 – 1.9)x10^{21}$ POT/yr

Pulse duration: 10 μs

Beam size at target:
tunable 1.0 - 4.0 mm
Present size ~2.7 mm

Parameter	Protons per cycle	Cycle Time (sec)	Beam Power (MW)
≤ 1.2 MW Operation - Current Maximum Value for LBNF			
Proton Beam Energy (GeV):			
60	7.5E+13	0.7	1.03
80	7.5E+13	0.9	1.07
120	7.5E+13	1.2	1.20
≤ 2.4 MW Operation - Planned Maximum Value for LBNF 2nd Phase			
Proton Beam Energy (GeV):			
60	1.5E+14	0.7	2.06
80	1.5E+14	0.9	2.14
120	1.5E+14	1.2	2.40

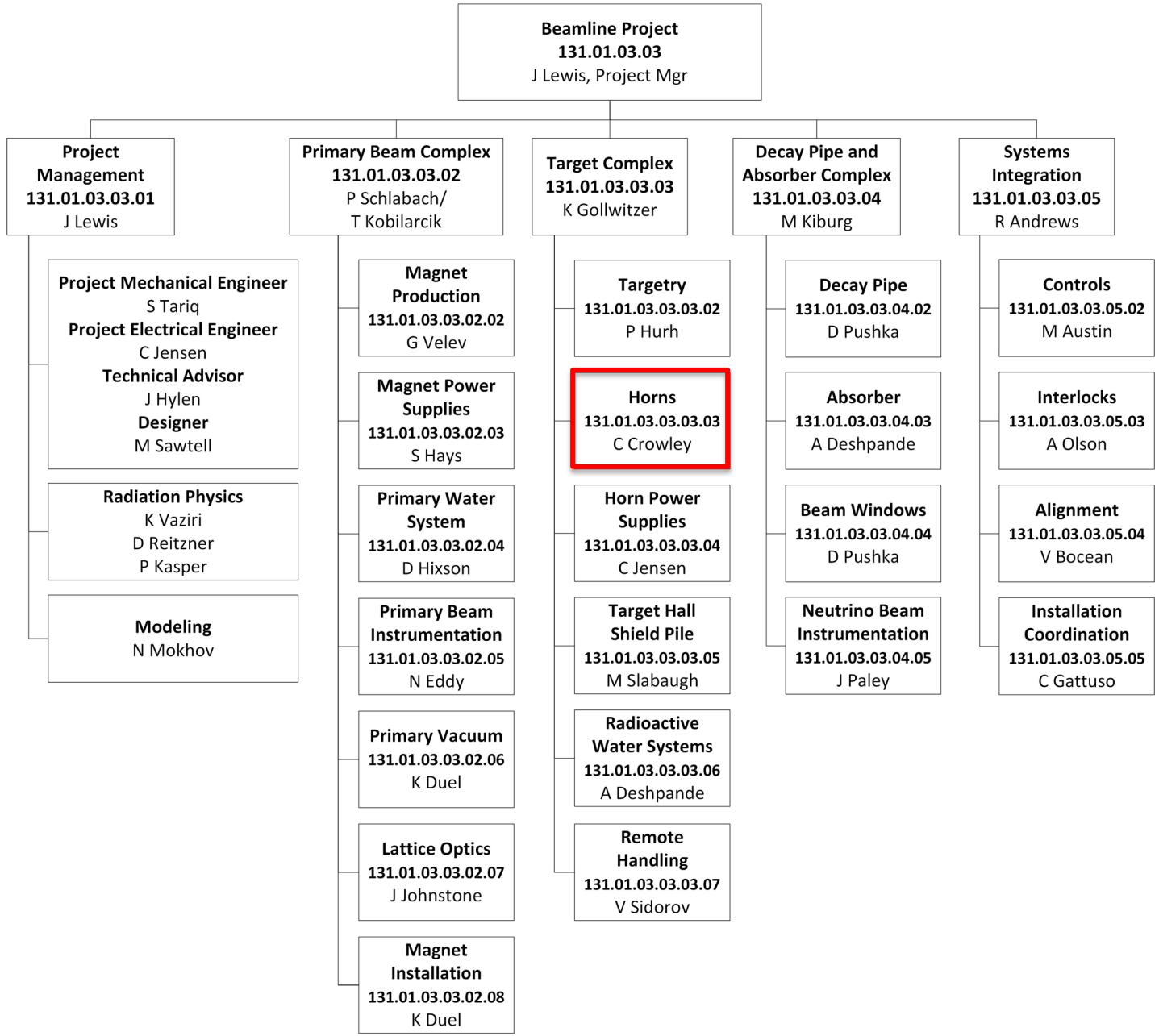
- Some Tevatron, NuMI components and some existing Fermilab steel available to LBNF – Project is developing MOA with laboratory
- Actively implementing lessons learned from MiniBooNE, NuMI/MINOS, NuMI/NOvA, JPARC and other Neutrino Facilities.

Systems being designed for 2.4 MW

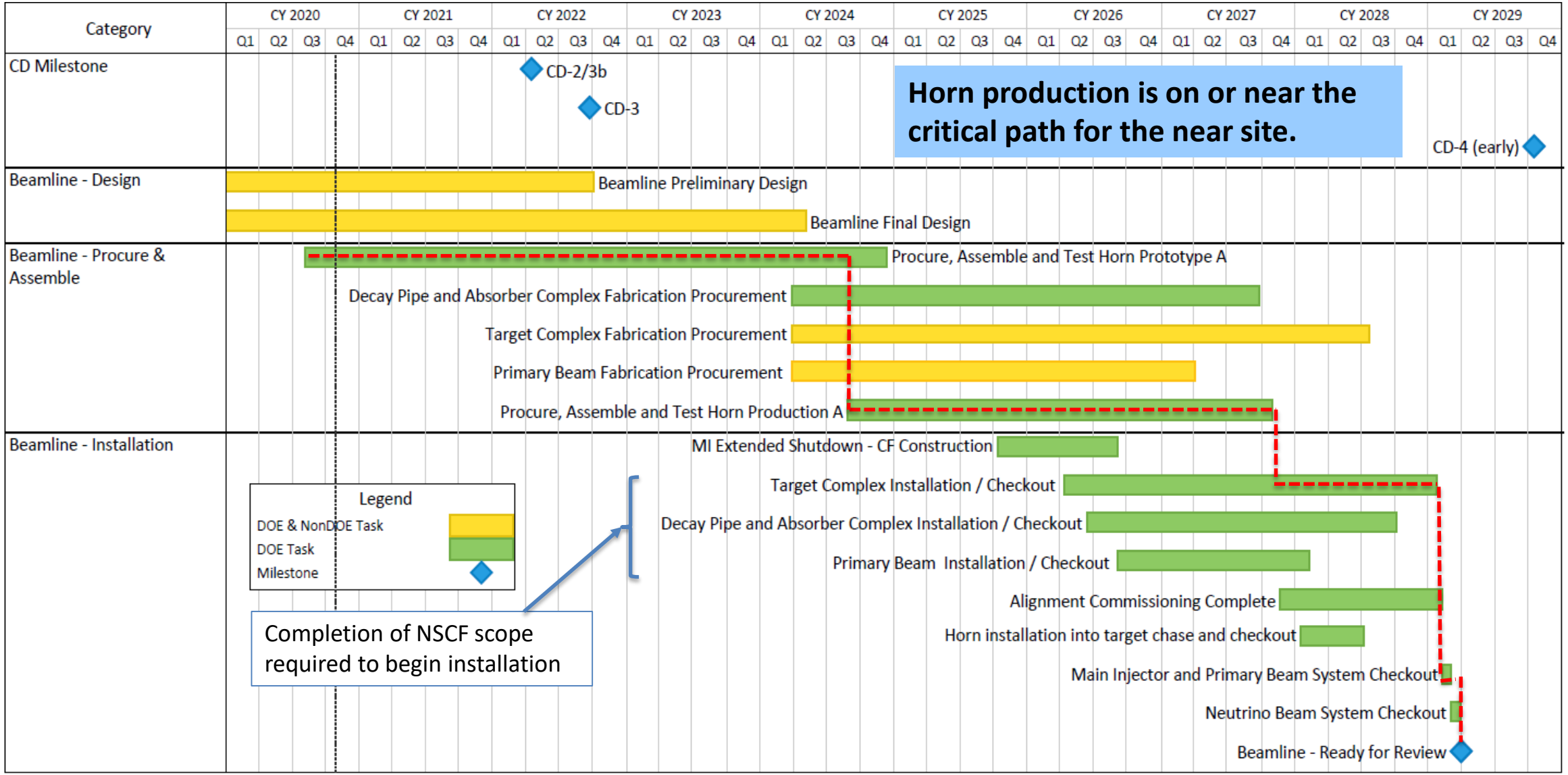
- Upgrading these items later would be prohibitively expensive and inconsistent with ALARA:
  - Size of enclosures (primary proton beamline, target chase, target hall, decay pipe, absorber hall)
  - Radiological shielding of enclosures
  - Primary Beamline components
  - Target chase cooling panels
  - Decay pipe, its cooling and the decay pipe downstream window
  - Hadron Absorber
  - Remote handling equipment
  - Radioactive Water (RAW) system piping
  - Horn support structures are designed to last for the facility lifetime

Organization

Horns task maintains written interfaces with other project elements



Beamline Schedule Summary



Horn A Prototype

- Technology Demonstrator
  - Prototype tests essential technologies and feature designs that are common to all horns
    - Only other prototype needed is larger stripline for Horns B and C
  - Time critical
    - Horn production is on the near-site critical path
- Role
  - It is fundamentally a prototype
    - Project risk register has an opportunity to use it as production if (and only if) no significant changes are required
      - Possible also to scavenge parts
    - It is necessarily ahead of elements that have interfaces with horns
      - Design evolution on either side may lead to changes
  - Learn from construction and testing of this horn and retire risk prior to assembly of production horns

This Review

- Narrow scope
  - Focused on the design of this horn
    - Not the services that work with it
    - Not the other horns
    - Production readiness questions cover only long-lead items
      - Needed for immediate purchase to stay on schedule
  - If the review leads to broader questions about the project, please send those concerns to Keith Gollwitzer and me
    - Issue raised at Preliminary design review about time to swap a horn or target will be addressed in a review this summer
      - Scope includes aspects of many subsystems, so needs an integrated review
- We appreciate your help to make sure we get this right.